Translation of Amendment and Brief Statement under Article 19(1)

PATENT CLAIMS

1.(Amended) A method for producing a compound semiconductor single crystal by a liquid encapsulated Czochralski method, comprising:

containing a semiconductor raw material and an encapsulating material in a raw material melt-containing portion comprising a first crucible and a second crucible, the first crucible having a bottom and a cylindrical shape, and the second crucible being disposed in an inside of the first crucible and having a bottom portion thereof provided with a communication hole communicating with the first crucible;

melting the raw material by heating the raw material melt-containing portion; and

growing a crystal by making a seed crystal be in contact with a surface of the raw material melt in a state covered with the encapsulating material and by pulling up the seed crystal,

whereon an interface between a crystal and the raw material melt, the crystallization is done in such a way that a diameter of a growing crystal on the interface is consistent with an inner diameter of the second crucible,

wherein the diameter of the growing crystal is confined by the inner wall of the second crucible, and the crystal is grown by maintaining a surface of the growing crystal in a state covered with the encapsulating material until termination of crystal growth.

2. The method for producing a compound semiconductor single crystal as claimed in claim 1, wherein an amount of the encapsulating material to be added is set to an amount such that the encapsulating material is capable of filling a space generated between the growing crystal and the second crucible in accordance with the crystal growth and covering an entire surface of the growing crystal.

3. The method for producing a compound semiconductor single crystal as claimed in claim 2, wherein a crucible having a tapered structure in which an inner diameter of a bottom portion of the crucible is smaller than an inner diameter of a top portion of the crucible is used as the second crucible.

4. The method for producing a compound semiconductor single crystal as claimed in claim 3, wherein the second crucible has a side face thereof tilted with respect to a vertical direction within a range of 0.2° to

10°.

5. The method for producing a compound semiconductor single crystal as claimed in any one of claims 1 to 4, wherein the crystal growth is performed in a state of the second crucible being dipped in the raw material melt contained in the first crucible to a depth within a range of 10 mm to 40 mm.

6. The method for producing a compound semiconductor single crystal as claimed in any one of claims 1 to 5, wherein a diameter of the communication hole is not more than 1/5 of the inner diameter of the second crucible.

7. The method for producing a compound semiconductor single crystal as claimed in any one of claims 1 to 6, wherein a temperature gradient in the raw material melt is set to at least not more than 20°C/cm.

Brief statement under PCT Article 19(1)

In claim 1, by correcting "wherein a heater temperature is controlled so that a diameter of a growing crystal becomes approximately equal to an inner diameter of the second crucible" with "whereon an interface between a crystal and the raw material melt, the crystallization is done in such a way that a diameter of a growing crystal on the interface is consistent with an inner diameter of the second crucible, wherein the diameter of the growing crystal is confined by the inner wall of the second crucible", it is clarified that in the present invention it is by the inner wall of the second crucible that the diameter of the growing crystal is controlled.

With respect to the epitaxial growth method using a crystal growth apparatus having a double-crucible structure, and the LEC method wherein the crystal is grown while the surface thereof is covered with the liquid encapsulating material as described in the references, in any case the crystal is grown so that the diameter becomes smaller than the diameter of the inner crucible (i.e. the second crucible) by, for example, controlling the heater(there is a gap between the crystal and the inner crucible). In contrast with this aspect, in the present invention on an interface between a crystal and the raw material melt,

the crystallization is done in such a way that a diameter of a growing crystal on the interface is consistent with an inner diameter of the second crucible, and this clearly differs from what was disclosed in the references.

In the present invention, in order to control the diameter in accord with the inner diameter of the inner crucible, the temperature is lowed within the range of 0~10°C/min during the crystal growth process, hence the temperature fluctuation becomes extremely small, and the effect that production of, for example, a twin crystal can be prevented is obtained.

条約１９条（１）に基づく説明書

請求の範囲第１項において、「成長結晶の直径が前記第２のルツボの内径と略同一となるようにヒータ温度を制御し、」とあるのを、「結晶と原料融液との界面において成長結晶の直径が前記界面における前記第２のルツボの内径と一致するように結晶化させ、前記第２のルツボの内壁によって前記成長結晶の直径を制御し、」と補正し、本願発明では成長結晶の直径が第２ルツボの内壁によって制御されることを明確にした。

引用文献には２重ルツボ構造の結晶成長装置を用いたエピタキシャル成長方法、および液体封止剤で表面を覆いながら結晶を成長させるＬＥＣ法に関する記載があるが、何れの文献でもヒータ制御等により直径が内ルツボ（第２のルツボ）の直径よりも小さくなるように結晶を成長させている（結晶と内ルツボの内壁との間に隙間がある）。これに対して、本願発明では結晶と原料融液との界面において成長結晶の直径が前記界面における内ルツボの内径と一致するように結晶化させているので、引用文献とは明らかに異なる。

本願発明では、内ルツボの内径に合わせて直径を制御するため、結晶成長過程において温度を０～１０℃／ｍｉｎの範囲で降温するだけでよいので、温度揺らぎが極めて小さくなり双晶等の欠陥を抑制することができるという効果がある。

請求の範囲

１．有底円筒形の第１のルツボと、該第１のルツボの内側に配置され底部に前記第１のルツボとの連通孔を設けた第２のルツボとから構成された原料融液収容部に半導体原料と封止剤を収容し、前記原料収容部を加熱して原料を溶融させ、前記封止剤に覆われた状態で該原料融液表面に種結晶を接触させて該種結晶を引き上げながら結晶成長させる液体封止チョクラルスキー法による化合物半導体単結晶の製造方法であって、

結晶と原料融液との界面において成長結晶の直径が前記界面における前記第２のルツボの内径と一致するように結晶化させ、前記第２のルツボの内壁によって前記成長結晶の直径を制御し、結晶成長が終了するまで成長結晶の表面が前記封止剤に覆われた状態を保持しながら結晶を成長させることを特徴とする化合物半導体単結晶の製造方法。

２．前記封止剤の添加量は、結晶成長に伴い成長結晶と前記第２のルツボとの間に生じた空間を充填し成長結晶の表面全体を覆うことが可能な量に設定することを特徴とする請求項１に記載の化合物半導体単結晶の製造方法。

３．前記第２のルツボとしてルツボ上部の内径よりルツボ底部の内径の方が小さいテーパー構造を有するルツボを用いることを特徴とする請求項１または請求項２に記載の化合物半導体単結晶の製造方法。

４．前記第２のルツボは、側面が鉛直方向に対して０．２°から１０°の範囲で傾斜していることを特徴とする請求項３に記載の化合物半導体単結晶の製造方法。

５．前記第１のルツボに収容された原料融液に前記第２のルツボが１０ｍｍから４０ｍｍの範囲で浸漬された状態で結晶成長を行うことを特徴とする請求項１から請求項４の何れかに記載の化合物半導体単結晶の製造方法。

６．前記連通孔の直径を前記第２のルツボの内径の１／５以下とすることを特徴とする請求項１から請求項５の何れかに記載の化合物半導体単結晶の製造方法。